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Tillman

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(54) **AD HOC NETWORKING**

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(52) **U.S. Cl.**
CPC .................................. *H04L 12/5695* (2013.01)

(58) **Field of Classification Search**
CPC ............................ H04L 47/70; G06F 17/3089
USPC ........... 709/235, 242; 370/235, 401, 254, 252
See application file for complete search history.

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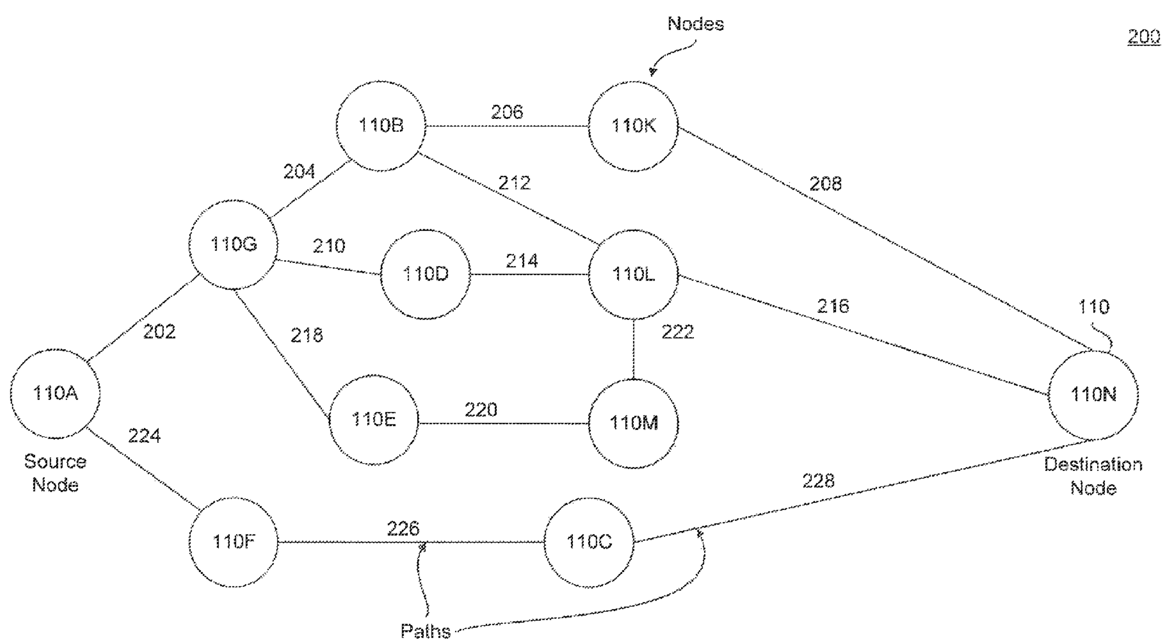
(57) **ABSTRACT**

Embodiments disclosed herein relate to ad hoc networking. An embodiment includes computing a routing score for a source node based on at least hardware capabilities of the source node, applications available to the source node, and networking capabilities of the source node. The embodiment further includes receiving at the source node, one or more routing scores from intermediate nodes directly or indirectly connected to the source node, and sending the data to the destination node based on at least the routing scores received from each intermediate node and one or more route paths associated with each intermediate node.

**11 Claims, 10 Drawing Sheets**



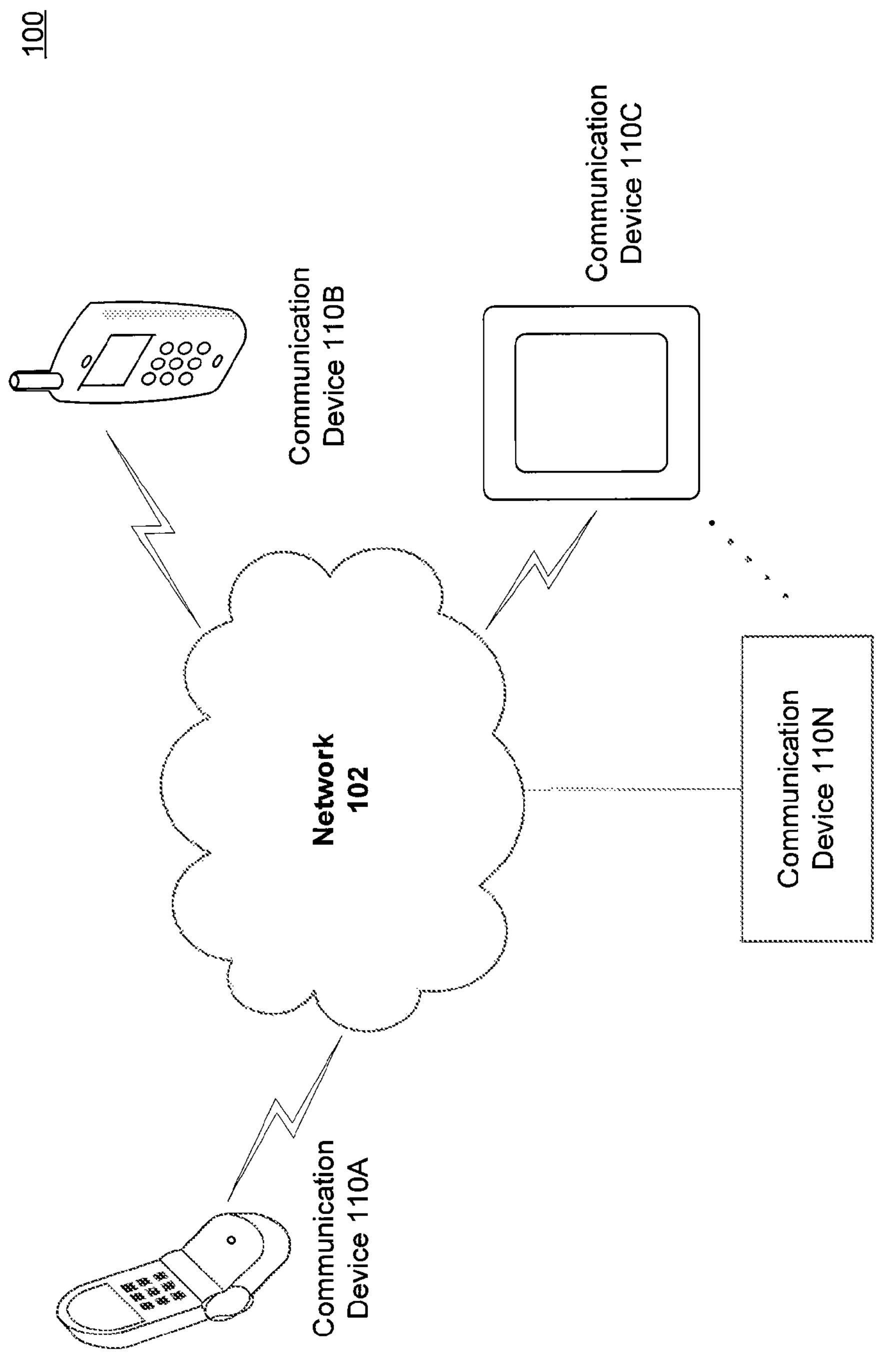

100
Communication Device 110B
Communication Device 110C
Network 102
Communication Device 110N
Communication Device 110A

FIG. 1

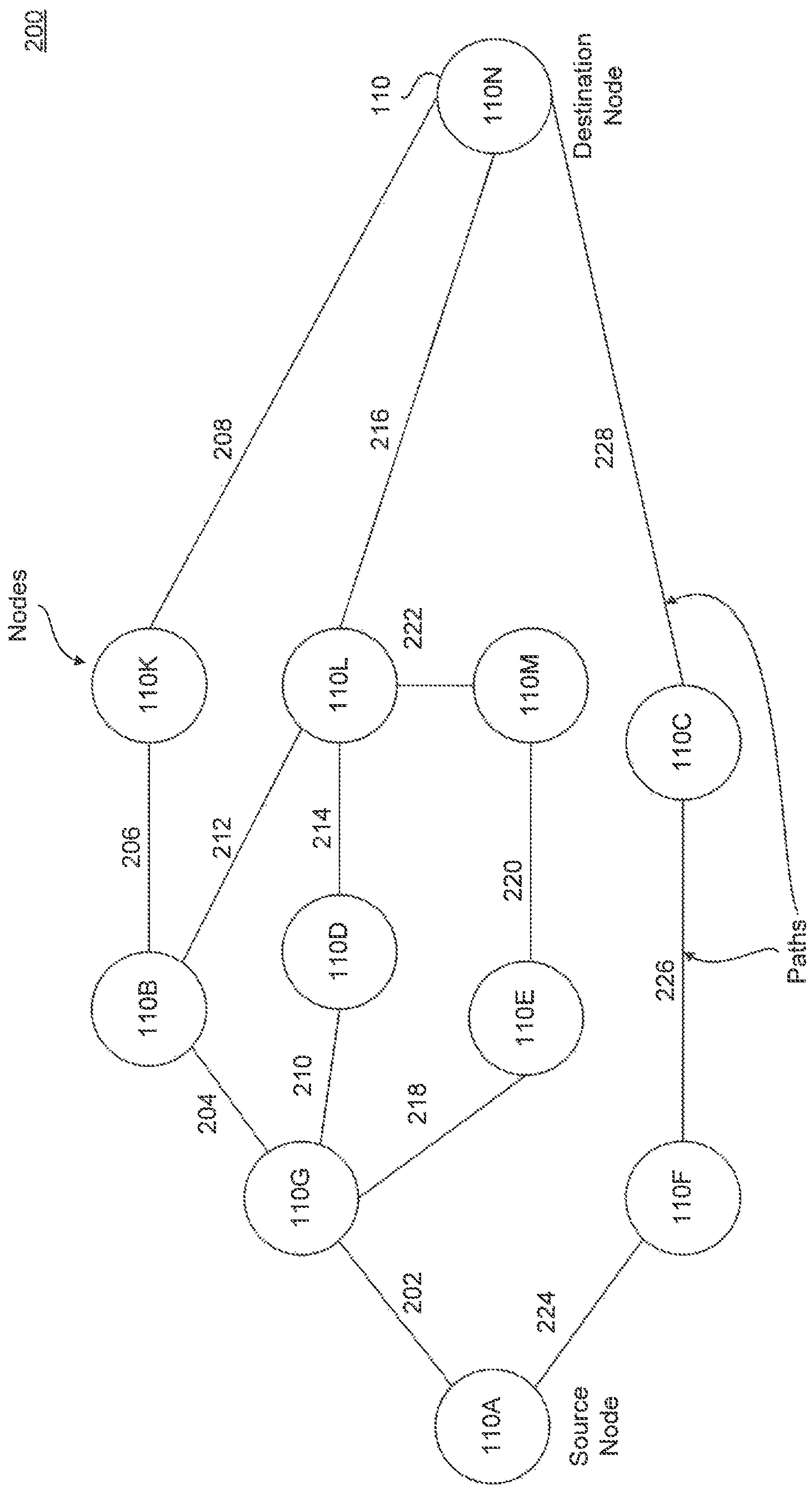

200
110
110N
Destination Node
208
216
228
Nodes
110K
110L
222
110M
110C
206
212
214
220
110B
110D
110E
226
Paths
204
210
218
110G
110F
202
224
110A
Source Node

FIG. 2

300

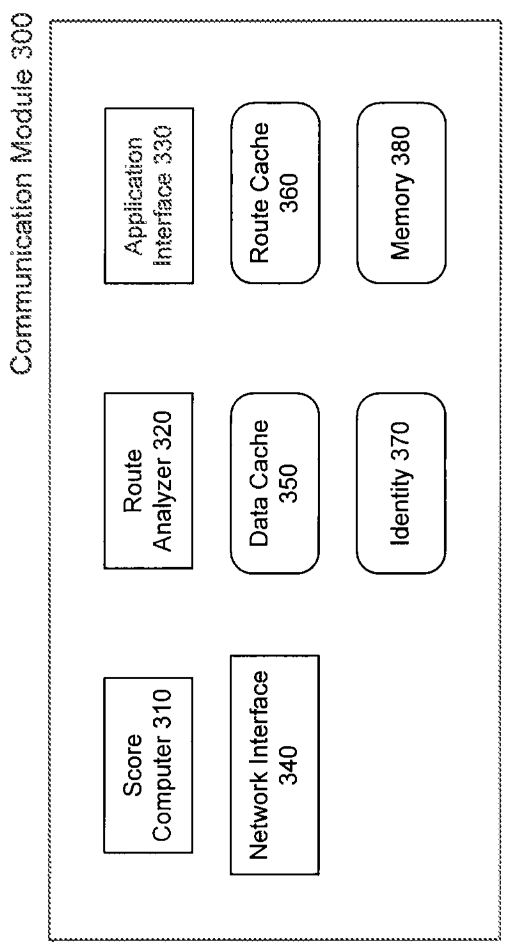
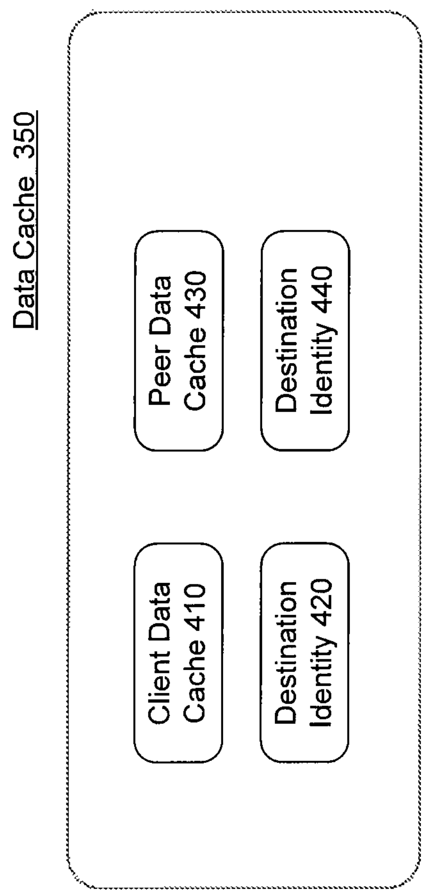

Communication Module 300
Score Computer 310
Route Analyzer 320
Application Interface 330
Network Interface 340
Data Cache 350
Route Cache 360
Identity 370
Memory 380

FIG. 3



Data Cache 350
Client Data Cache 410
Destination Identity 420
Peer Data Cache 430
Destination Identity 440


FIG. 4

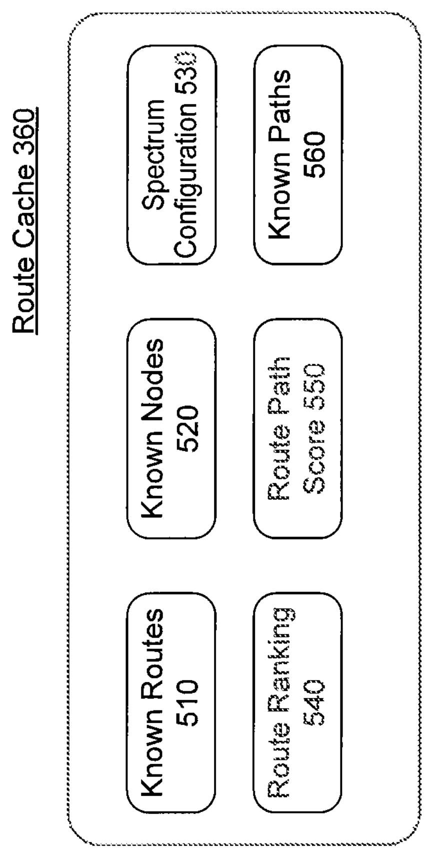

Route Cache 360
Known Routes 510
Known Nodes 520
Spectrum Configuration 530
Route Ranking 540
Route Path Score 550
Known Paths 560

FIG. 5

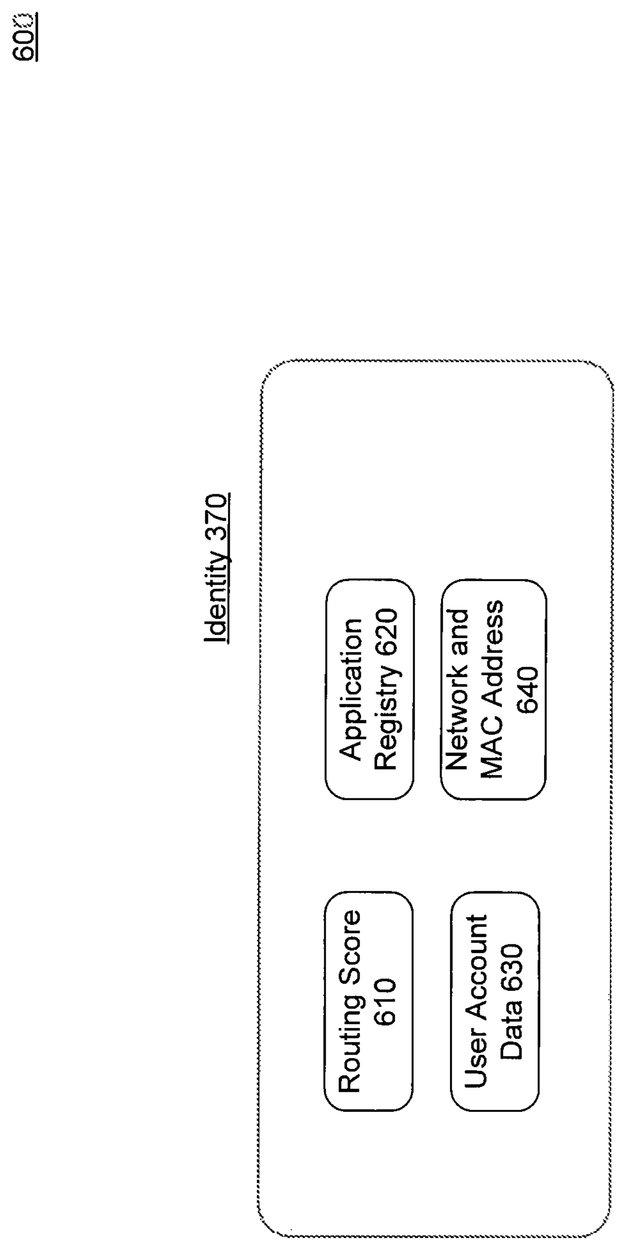

600
Identity 370
Routing Score 610
Application Registry 620
User Account Data 630
Network and MAC Address 640

FIG. 6

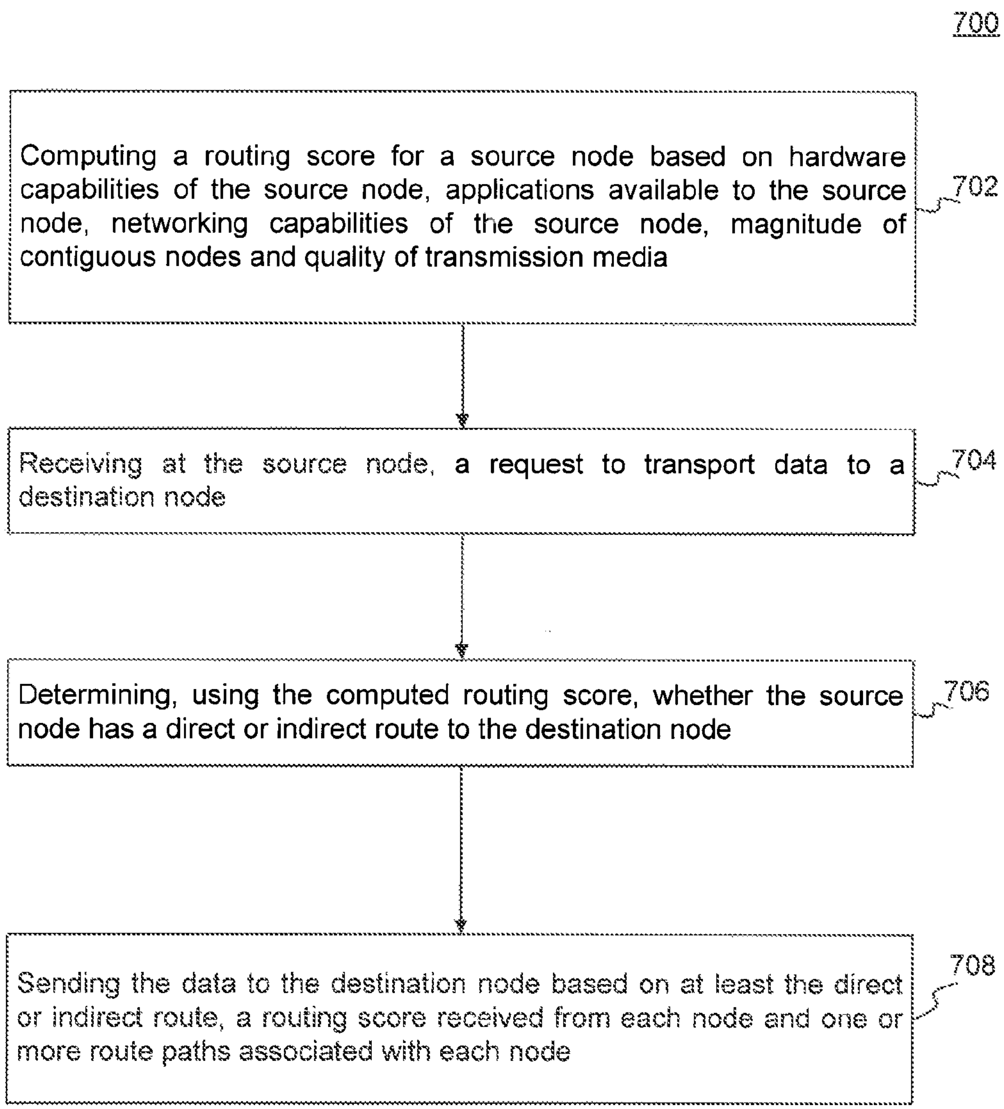

700
Computing a routing score for a source node based on hardware capabilities of the source node, applications available to the source node, networking capabilities of the source node, magnitude of contiguous nodes and quality of transmission media
702
Receiving at the source node, a request to transport data to a destination node
704
Determining, using the computed routing score, whether the source node has a direct or indirect route to the destination node
706
Sending the data to the destination node based on at least the direct or indirect route, a routing score received from each node and one or more route paths associated with each node
708

FIG. 7

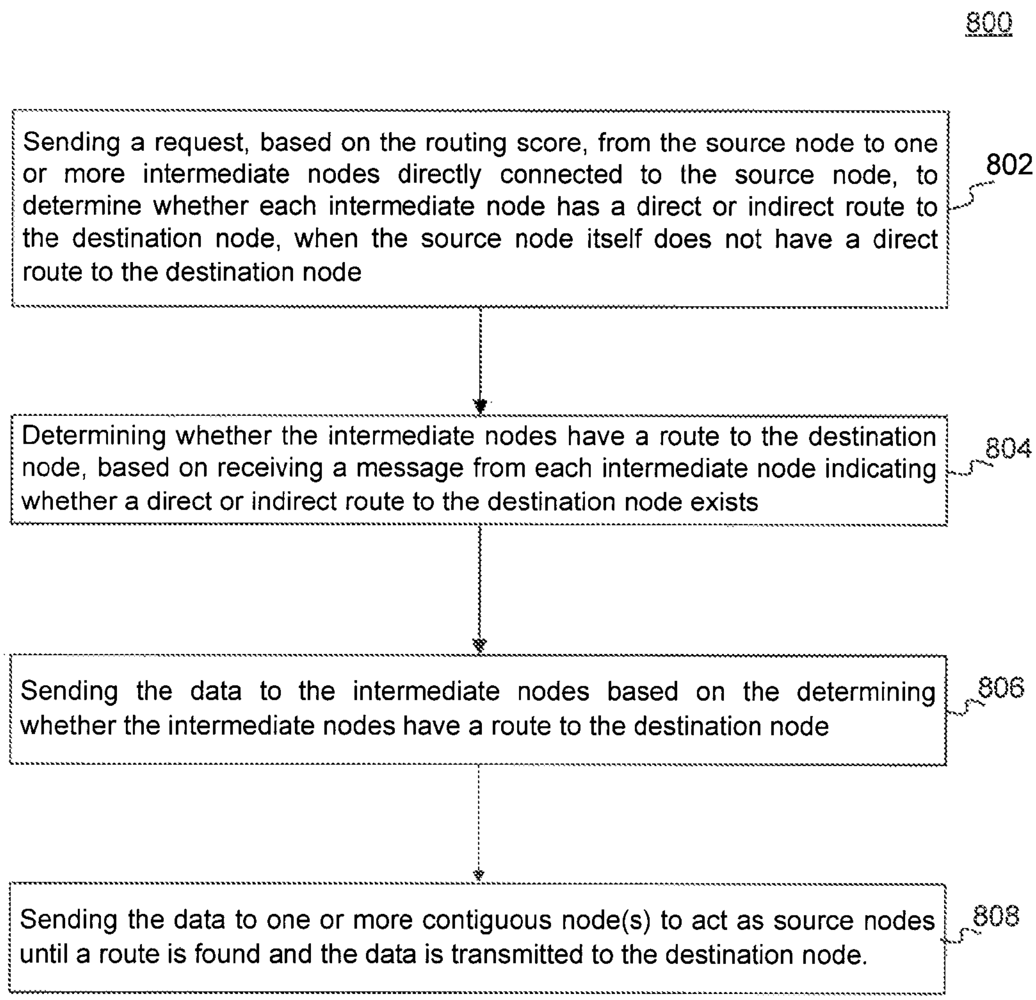

800
Sending a request, based on the routing score, from the source node to one or more intermediate nodes directly connected to the source node, to determine whether each intermediate node has a direct or indirect route to the destination node, when the source node itself does not have a direct route to the destination node
802
Determining whether the intermediate nodes have a route to the destination node, based on receiving a message from each intermediate node indicating whether a direct or indirect route to the destination node exists
804
Sending the data to the intermediate nodes based on the determining whether the intermediate nodes have a route to the destination node
806
Sending the data to one or more contiguous node(s) to act as source nodes until a route is found and the data is transmitted to the destination node.
808

FIG. 8

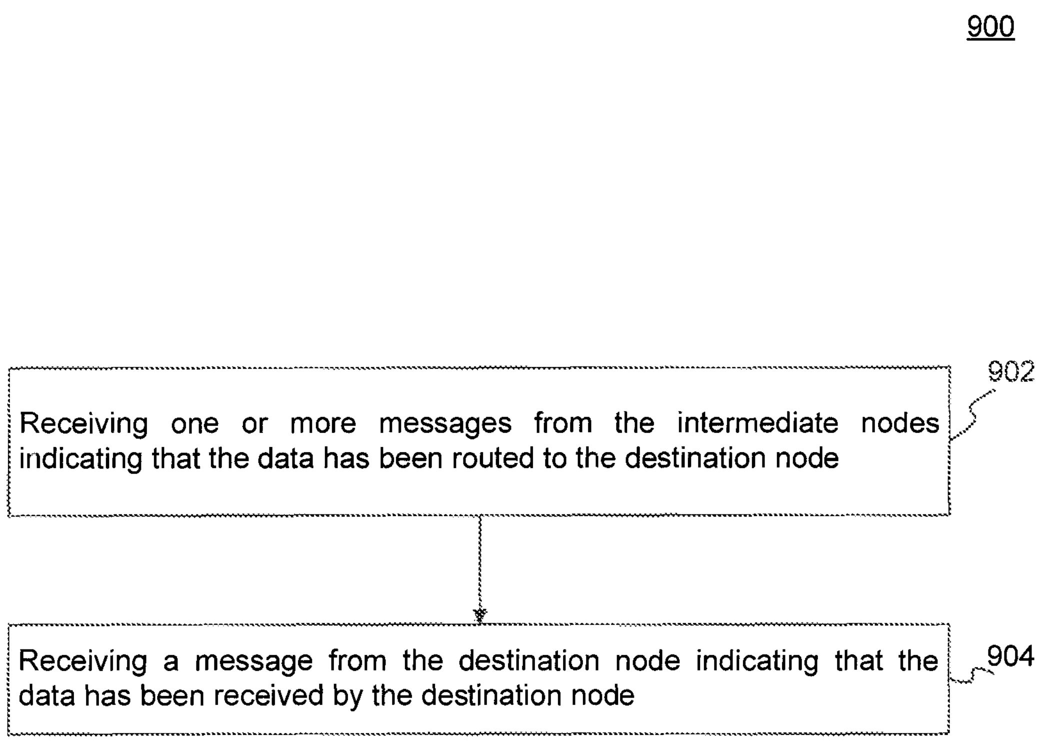

900
902
Receiving one or more messages from the intermediate nodes indicating that the data has been routed to the destination node
904
Receiving a message from the destination node indicating that the data has been received by the destination node

FIG. 9

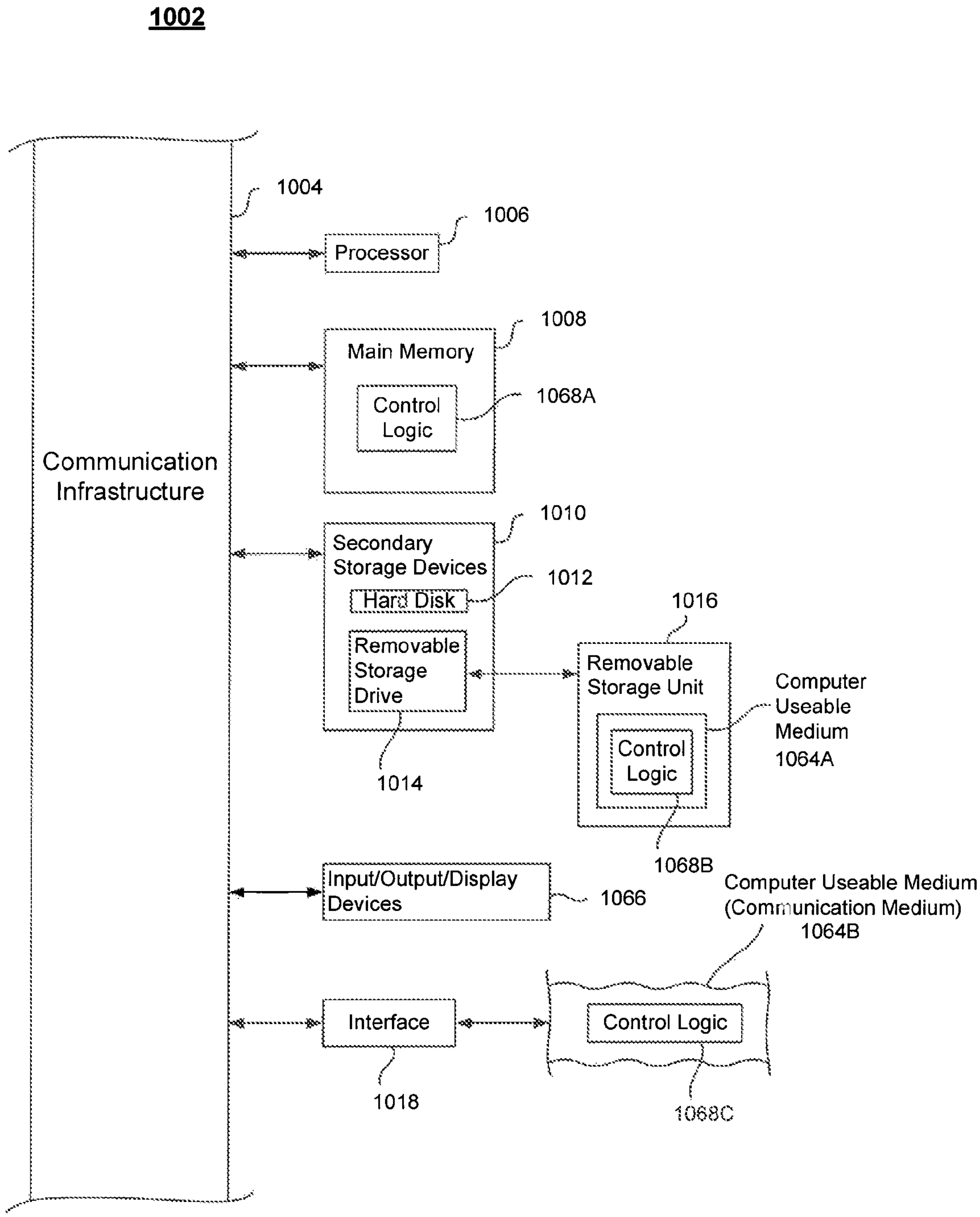

1002
1004
Communication Infrastructure
Processor
1006
Main Memory
1008
Control Logic
1068A
Secondary Storage Devices
1010
Hard Disk
1012
Removable Storage Drive
1014
1016
Removable Storage Unit
Control Logic
Computer Useable Medium 1064A
1068B
Input/Output/Display Devices
1066
Computer Useable Medium (Communication Medium)
1064B
Interface
1018
Control Logic
1068C

FIG. 10

# AD HOC NETWORKING

## BACKGROUND

1. Field

Embodiments generally relate to computer networking.

2. Background Discussion

The Internet is considered to be a communication backbone for private, public, academic, business, and government networks, of local to global scope. Connecting to the Internet and other similar communication infrastructures has become a necessity.

Conventional networks rely on a number of gateway servers, wired access points or wireless hotspots to enable users to connect to the Internet. These servers are generally maintained and operated by Internet Service Providers (ISPs). When user access to a gateway server is affected, users are unable to connect to the Internet or other similar communication networks. This prevents a user from conveniently and rapidly communicating with other users. Furthermore, conventional networking techniques generally utilize cabling (e.g., copper cabling) leading to increased network infrastructure costs when creating new networks. Such cable-based infrastructure also tends to limit geographical areas serviced by networks.

## BRIEF SUMMARY

Embodiments relate to ad hoc networking. One innovative aspect of the subject matter described includes a method including computing a routing score for a source node based on at least hardware capabilities of the source node, applications available to the source node, and networking capabilities of the source node. The embodiment further includes receiving at the source node, one or more routing scores from intermediate nodes directly or indirectly connected to the source node, and sending the data to the destination node based on at least the routing scores received from each intermediate node and one or more route paths associated with each intermediate node.

The method further comprises instantiating a communication module on the source node, the communication module configured to perform the computing, the receiving, and the sending, where the communication module may communicate with other communication modules to establish and maintain an independent ad hoc network adaptable to changing network conditions. In an embodiment, the routing score can also be based on a magnitude of contiguous node(s) and quality of transmission media.

Other embodiments of this aspect include corresponding systems, apparatus, and computer programs, configured to perform the actions of the methods, encoded on computer storage devices.

Further embodiments, features, and advantages of the embodiments, as well as the structure and operation of the various embodiments are described in detail below with reference to accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments are described with reference to the accompanying drawings. In the drawings, like reference numbers may indicate identical or functionally similar elements. The drawing in which an element first appears is generally indicated by the left-most digit in the corresponding reference number.

FIG. **1** illustrates an example network environment.



FIG. **2** illustrates a graph that includes nodes representing communication devices.

FIG. **3** illustrates a diagram of a communication module.

FIG. **4** illustrates a diagram of a data cache.

FIG. **5** illustrates a diagram of a route cache.

FIG. **6** illustrates a diagram of a node identity.

FIG. **7** is a flowchart illustrating overall operation of a communication module.

FIG. **8** is a flowchart illustrating sending data to a destination node.

FIG. **9** illustrates receiving messages from intermediate nodes and a destination node.

FIG. **10** illustrates an example computer system.

## DETAILED DESCRIPTION

Embodiments relate to ad hoc networking. As discussed above, an embodiment includes computing a routing score for a source node, where the source node represents a communication device in a graph comprising nodes representing communication devices. In one embodiment, the routing score is based on at least hardware capabilities of the source node, applications available to the source node (e.g., installed applications), networking capabilities of the source node, a magnitude (or number) of contiguous node(s) and quality of transmission media. As a non-limiting example, contiguous nodes are nodes which are in direct contact (or in proximity) with each other or a given node.

The embodiment further includes receiving at the source node, one or more routing scores from intermediate nodes directly or indirectly connected to the source node, and sending the data to the destination node based on at least the routing scores received from each intermediate node and one or more route paths associated with each intermediate node.

The embodiment further includes instantiating a communication module on the source node, the communication module configured to perform the computing, the receiving, and the sending, where the communication module may communicate with other communication modules to establish and maintain an independent ad hoc network adaptable to changing network conditions. In an embodiment, the routing score can also be based on a magnitude of contiguous node(s) and quality of transmission media.

In one embodiment, these operations (e.g., computing of a routing score and sending of data) may be performed by a communication module instantiated on each of communication devices illustrated by the nodes in the graph of communication devices. In one embodiment, these instantiated communication modules communicate with each other to enable transport of data across the nodes (i.e., communication devices), using alternative communication networks (or frequency spectrums) available to the communication devices, when one or more preferred networking methods (e.g., Internet) utilized by the communication devices have been disrupted or disabled.

In other words, the communication modules instantiated on each of the nodes establish an ad hoc and independent network that can dynamically adapt to changing network conditions. In this way, embodiments enable users to conveniently communicate and network with other users using the ad hoc and independent network established by the communication modules when conventional networks utilized, by the nodes are disrupted or disabled. Furthermore, the ad hoc and independent network established by the communication modules does not use physical cabling to instantiate the network and is therefore not limited by cabling and associated geographical coverage constraints.

While the present embodiments are described herein with reference to illustrative applications, it should be understood that the embodiments are not limited thereto. Those skilled in the art with access to the teachings provided herein will recognize additional modifications, applications, and embodiments within the scope thereof and additional fields in which the embodiments would be of significant utility.

FIG. **1** illustrates a network environment **100** in which embodiments may be implemented. The embodiments are applicable to any environment having generally the structure of FIG. **1**, or that would benefit from the operation, methods and functions as described herein.

Network environment **100** includes network **102** and communication devices **110**A-N. Communication devices **110**A-N can each be any type of computing (or processing) device having one or more processors. For example, communication devices **110**A-N can each be a workstation, mobile device, computer, cluster of computers, set-top box, robotic device, appliance or other device having at least one processor. Such a communication device may include software, firmware, hardware, or a combination thereof. Software may include one or more applications and an operating system. Hardware can include, but is not limited to, a processor, memory and graphical user interface display.

In one embodiment, communication devices **110**A-N can support email communication and network-based communication. For example, communication devices **110**A-N can be mobile phones or tablet computers that support email communication, Internet browsing and/or access to a cloud computing infrastructure. An optional input device, such as a mouse or a Bluetooth headset, may be used. Communication devices **110**A-N can be connected to network **102** using a physical wire medium (e.g., cables) or can communicate with network **102** over a wireless medium (e.g., WiFi). Furthermore, communication devices **110**A-N can have the ability to communicate over any channel in any frequency spectrum.

Network **102** may include one or more networks, including but not limited to, a local area network, medium-area network, and/or wide-area network, such as the Internet. Network **102**, for example, may be any form of wired or wireless network that allows communication devices **110**A-N, and any additional clients, servers, systems and appliances to communicate with each other.

FIG. **2** is a diagram illustrating a graph **200**. Graph **200** includes nodes **110**A-N corresponding to communication devices **110**A-N. Graph **200** is a graphical representation of communication paths **202**-**228** that may exist between communication devices **110**A-N. Because nodes **110**A-N graphically represents communication devices **110**A-N, a reference to nodes **110**A-N as used herein also indicates reference to corresponding communication devices **110**A-N and vice versa. Referring to FIG. **2**, node **110**A may establish a communication path (or "path") **202** to communicate with node **110**G.

In graph **200**, node **110**A acts as a source node (hereinafter referred to as "source node **110**A") and node **110**N is a destination node (hereinafter referred to as "destination node **110**N"). Referring to FIG. **2**, one possible data transport path from source node **110**A to destination node **110**N can be through paths **202**-**204**-**206** and **208**, i.e., through nodes **110**G, **110**B, and **110**K. Another possible data transport path from source node **110**A to destination node **110**N can be through paths **202**-**218**-**220**-**222** and **216** i.e., through nodes **110**G, **110**E, **110**M and **110**L. Assuming that node **110**G is or becomes disabled or not operational, source node **110**A can transport data to destination node **110**N along path **224**-**226**-**228** i.e., through nodes **110**F and **110**C.

It is to be appreciated that graph **200** illustrates nodes for the purposes of illustration and not limitation and that any other node in graph **200** may act as a source node or a destination node. In one embodiment, any node in graph **200** acts as a source node when it is sending data and acts as a destination node when receiving data from another node. Reference will be made to graph **200** in discussions below.

FIG. **3** illustrates a communication module **300**, according to an embodiment. In one embodiment, communication module **300** can be implemented or instantiated on nodes **110**A-N. In one embodiment, communication module **300** is implemented as a client module on each of nodes **110**A-N. In one embodiment, communication module **300** can be downloaded by respective users of nodes **110**A-N.

In one embodiment, communication module(s) **300**, instantiated on each of nodes **110**A-N, enable transport of data across the nodes (e.g., nodes **110**A-N), using alternative communication networks (or frequency spectrums) available to the nodes, when, for example, one or more preferred networking methods (e.g., Internet) utilized by the nodes are disabled or disrupted. In another non-limiting embodiment, communication module(s) **300** enable transport of data across the nodes (e.g., nodes **110**A-N), using alternative communication networks (or frequency spectrums) available to the nodes at any time and over any frequency channel.

In one embodiment, and as illustrated in FIG. **3**, communication module **300** further includes score computer **310**, route analyzer **320**, application interface **330**, network interface **340**, data cache **350**, route cache **360**, identity **370**, and memory **380**.

In one embodiment, score computer **310** is configured to compute a routing score for a source node based on at least hardware capabilities of the source node, applications available to the source node (e.g., installed applications), networking capabilities of the source node, a magnitude (or number) of contiguous node(s) and quality of transmission media.

As an illustrative and non-limiting example, a routing score can be a number (or any identifier/value) self-computed (and updated) by each node **110**A-N. For example, source node **110**A computes a routing score for itself based on at least its hardware capabilities, applications available to (or installed on) itself, and also its networking capabilities.

Hardware capabilities may include computing resources (e.g., processor(s), memory, etc.) available to source node **110**A. Networking capabilities include network adapters (e.g., WiFi, Bluetooth adapters) and communication channels that are available to source node **110**A. Applications available to the source node (or software capabilities) may include any applications, including, but not limited to, messaging applications and social networking applications.

In one embodiment, source node **110**A receives a request to transport data to destination node **110**N from a social networking application installed on source node **110**A. In another embodiment, source node **110**A receives a request to transport data to destination node **110**N from a messaging application installed on source node **110**A. Because communication module(s) **300** installed on each node **110**A-N communicate with each other to enable transport of data across the nodes **110**A-N, using any communication networks (or frequency spectrums) available to the nodes, when one or more preferred networking methods (e.g., Internet) utilized by the nodes have been disabled, data transmitted by the social networking and messaging applications installed on source node **110**A can still be delivered to destination node **110**N.

In other words, communication modules **300** installed on nodes **110**A-N establish an ad hoc and independent network that can dynamically adapt to changing network conditions, such as the creation and elimination of available communication channels. In this way, embodiments enable users to conveniently communicate and network with other users using the network established by communication modules **300**.

Returning to FIG. **3**, In one embodiment, route analyzer **320** determines, using a routing score computed by source node **110**A, whether source node **110**A has a direct or indirect route to destination node **110**N and sends data to destination node **110**N based on at least the direct or indirect route, a routing score received from each node in graph **200** and one or more route paths associated with each node in graph **200**.

In one embodiment, route analyzer **320** sends a request, based on the routing score, from source node **110**A to one or more intermediate nodes directly connected to the source node **110**A (e.g., nodes **110**F and **110**G), to determine whether each intermediate node (i.e., nodes **110**F and **110**G) has a direct or indirect route to destination node **110**N, when source node **110**A itself does not have a direct route to destination node **110**N.

In this way, route analyzer **320** determines whether intermediate nodes have a route to a destination node, based on receiving a message (e.g., routing score) from each intermediate node indicating whether a direct or indirect route to the destination node exists. Source node **110**A then sends the data to the intermediate nodes based on the determining whether the intermediate nodes have a direct or indirect route to destination node **110**N. For example, referring to FIG. **2**, node **110**D may send a message to source node **110**A indicating that node **110**D has an indirect route (i.e., path **214** and **216**) to destination node **110**N via node **110**L. Node **110**K may send a message to source node **110**A indicating that node **110**K has a direct route (i.e., path **208**) to destination node **110**N. Other nodes in the graph may transmit similar messages.

Also, in a non-limiting embodiment, once data is sent from source node **110**A to an intermediate node, e.g., node **110**G, the intermediate node, i.e., node **110**G, now acts as a source node for the data. Nodes directly connected to node **110**G are nodes **110**B, D and E. Thus, nodes **110**B, D and E can act as intermediate nodes for any data transmitted by node **110**G. In addition, nodes **110**B, D and E are also intermediate nodes with respect to source node **11** OA because node **110**G is connected to source node **11** OA.

In one embodiment, each node in graph **200** reports its routing score to its respective directly connected intermediate nodes. In another embodiment, each node in graph **200** reports its routing score to any node(s) in graph **200**.

In one embodiment, source node **110**A (and any other nodes) compute a route path score that is a function of source node **110**A's routing score, reported routing scores of any intermediate and destination nodes and also a magnitude (or number) of communication paths available to source node **110**A. As a purely illustrative example, the computed route path score can be any number, character, identifier (or any combination thereof) that is based on that is a function of source node **110**A's routing score, reported routing scores of any intermediate and destination nodes and also a magnitude (or number) of communication paths available to source node **110**A

As noted above and In one embodiment, once source node **110**A transports the data to an intermediate node (e.g., node **110**G), that intermediate node acts as a source node to further transport data to its respective intermediate nodes (e.g., **110**B, D and E) for eventual routing to destination node **110**N.

In this way, each node along a route path to a destination node can act as a source node and/or intermediate node. Furthermore, each node in graph **200** has its respective communication module **300** instantiated on itself that enables each node to compute and report its respective routing score as well as transport data to other nodes in graph **200**. Thus, communication modules **300** installed on nodes **110**A-N establish an ad hoc and independent network that can dynamically adapt to changing network conditions (e.g., network disruption). In this way, embodiments enable users to conveniently communicate and network with other users using the ad hoc and independent network established by communication modules **300**.

Returning to FIG. **3**, In one embodiment, application interface **330** acts as an application program interface (API) that enables software applications to access capabilities of communication module **300**. For example, a messaging application can provide commands to communication module **300** using application interface **330** to transport messages generated by the messaging application to destination node **110**N. In a non-limiting embodiment, access to application interface **330** may be provided based on receipt of a unique identifier from an application. Such a unique identifier may be based on a combination of a unique user identifier (ID) (e.g., username) and a unique device ID (e.g., MAC/network address).

In one embodiment, network interface **340** can include any network adapter configured to communicate over one or more wired and/or wireless communication channel(s). In one embodiment, network interface **340** includes hardware that enables a node to connect to network **102**. In one embodiment, network interface **340** is associated with a unique media access control (MAC) address that may be used to identify a node in graph **200**. MAC addresses are known to those skilled in the art and are unique addresses used to identify network interfaces.

In one embodiment, data cache **350**, route cache **360**, identity **370** and memory **380** are configured to store data associated with operations of communication module **300** and are described below.

FIG. **4** illustrates data cache **350**, according to an embodiment. Data cache **350** includes client data cache **410**, destination identity **420**, peer data cache **430** and destination identity **440**.

In one embodiment, data cache **350** is used by a node to store data that is pending transmission. This transmission can include a transmission initiated by the node as well as a transmission for which the node is acting as an intermediate node.

In one embodiment, client data cache **410** of a node stores data originating from the node. In one embodiment, peer data cache **430** stores data that is being transported via the node, i.e., transported when the node is acting as an intermediate node.

In one embodiment, both client data cache **410** and peer data cache **430** are associated with their respective destination identities **420** and **440** that store data related to and identifying their respective destination nodes.

FIG. **5** illustrates a route cache **360**, according to an embodiment. In one embodiment, route cache **360** can store known routes **510**, known nodes **520**, spectrum configuration **530**, route ranking **540**, route path score **550** and known paths **560**.

In a non-limiting embodiment, route cache **360** is a persistent yet updatable data store that includes information relating to established network routes and their relative transmission quality.

In one embodiment, route cache **360** can dynamically update based on availability of additional network routes or any changes to existing network routes. Such changes can occur, for example, when nodes **110**A-N move to different locations. For example, when nodes **110**A-N are cellular devices, cell phone networks may change as the devices change locations during a user's travels. Such changes cause communication module **300** to automatically update data stored in route cache **360**. In one embodiment, nodes can query route caches of other nodes to determine useful routes.

In one embodiment, known routes **510** includes information relating to established network routes (e.g., the routes from source node **110**A to destination node **110**N discussed above). Known nodes **520** includes information relating to nodes (e.g., **110**G, **110**B, **110**K) that are known to a given node (e.g., source node **110**A).

Spectrum configuration **530** includes data relating to frequency spectrums available to a given node. For example, spectrum configuration **530** can include data relating to frequency channels available to a node, channels of acceptable quality that can be utilized for data transmission and noise levels associated with the channels. In one embodiment, route ranking **540** may include a list of available routes that are ranked based on their availability and quality of transmission media. As an illustrative example, a failed connection on a route may reduce a route rank of the route. For example, referring to FIG. **2**, when nodes **110**G, **110**B, **110**K are available and able to provide efficient low-loss data transmission as compared to other nodes in FIG. **2**, nodes **110**G, **110**B, **110**K may be ranked higher in route ranking **540** compared to other nodes in FIG. **2**. This example is purely illustrative and is not intended to limit the embodiments.

In one embodiment, route path score **550** for a given node can be a function of the node's own routing score, a reported routing score from other nodes associated with the node and a magnitude (or number) of known or possible paths (i.e., known paths **560**) to the other nodes from the given node.

FIG. **6** illustrates an exemplary identity **370**, according to an embodiment. In one embodiment, identity **370** can act as an abstract container (or data store) for one or more attributes and processes used to identify and enable discovery of a given node. In one embodiment, identity **370** further includes routing score **610**, application registry **620**, user account data **630** and network and MAC address **640**.

As discussed above, routing score **610** for a given node is a function of at least hardware capabilities of the node (e.g., source node **110**A), applications available to the node, and networking capabilities of the node. In another embodiment, the routing score can also be based a magnitude (or number) of contiguous nodes and quality of transmission media. Also, in one embodiment, routing score **610** can be dynamically updated by communication module **300** based on availability of additional network routes or any changes to existing network routes or nodes.

In one embodiment, application registry **620** for a given node is a dynamic list of applications installed on the node that are capable of interaction with network **102**. For example, these applications can be social networking or messaging applications. In one embodiment, these installed applications can communicate with communication module **300** using application interface **330**. In one embodiment, application registry **620** is dynamically updated by communication module **300** when applications are installed or uninstalled from a node.

In one embodiment, user account data **630** includes, but is not limited to, data that enables a user to log into the node (or communication device). In other words, and for example, user account data **630** can be a username and password pair used to authenticate and identify a user on network **102**.

In one embodiment, network and MAC address **370** for a given node can be used to identify the node, such as by reference to information representing the relationships illustrated in graph **200**. As a purely illustrative example, a node may send data to another node using the another node's MAC address. As an example, a MAC address can be a unique hardware identification code associated with network interface **340**.

FIG. **7** illustrates method **700**, which is an overall operation of a communication module, according to an embodiment.

In one embodiment, a routing score for a source node is computed, where the routing score is based on one or more of hardware capabilities of the source node, applications (e.g., social networking applications) available to the source node, and networking capabilities of the source node (step **702**).

A request to transport data to a destination node, such as a node in the graph of FIG. **2**, is received at the source node (step **704**). Using the computed routing score, it is determined whether the source node has a direct or indirect route to the destination node (step **706**). The data is sent to the destination node based on at least the direct or indirect route, a routing score received from each node and one or more route paths associated with each node (step **708**).

As discussed above, and according to an embodiment, steps **702**-**708** may be performed by communication module **300** instantiated on each node **110**A-N.

FIG. **8** illustrates method **800**, which is an operation of sending data from a source node to a destination node, according to an embodiment.

In one embodiment, a request, based on a routing score, is sent from the source node to one or more intermediate nodes directly connected to the source node, to determine whether each intermediate node has a direct or indirect route to the destination node, when the source node itself does not have a direct route to the destination node (step **802**).

Method **800** proceeds by determining whether the intermediate nodes have a route to the destination node, based on receiving a message from each intermediate node indicating whether a direct or indirect route to the destination node exists (step **804**). The data is then sent to the intermediate nodes based on the determining whether the intermediate nodes have a route to the destination node (step **806**). In a non-limiting embodiment, if no direct or indirect route is found, data is broadcast to appropriate contiguous node(s) to act as source nodes until a route is found and the data is transmitted to the destination node (step **808**). For example, source node **110**A may send data to other nodes that may be wirelessly available to source node **110**A.

FIG. **9** illustrates method **900**, which is an operation that receives messages from intermediate nodes and a destination node, according to an embodiment.

In one embodiment, one or more messages from the intermediate nodes indicating that the data has been routed to the destination node are received (step **902**). When the data is transported to the destination node from the intermediate nodes, a message from the destination node is received indicating that the data has been received by the destination node (step **904**).

In one embodiment, the system, methods and components of embodiments described herein are implemented using one or more computers, such as example computer **1002** shown in FIG. **10**. For example, communication module **300**, score computer **310** and route analyzer **320** can be implemented using computer(s) **1002**.

Computer **1002** can be any commercially available and well-known computer capable of performing the functions described herein, such as computers available from International Business Machines, Apple, Oracle, HP, Dell, Cray, etc.

Computer **1002** includes one or more processors (also called central processing units, or CPUs), such as a processor **1006**. Processor **1006** is connected to a communication infrastructure **1004**.

Computer **1002** also includes a main or primary memory **1008**, such as random access memory (RAM). Primary memory **1008** has stored therein control logic **1068**A (computer software), and data.

Computer **1002** also includes one or more secondary storage devices **1010**. Secondary storage devices **1010** include, for example, a hard disk drive **1012** and/or a removable storage device or drive **1014**, as well as other types of storage devices, such as memory cards and memory sticks. Removable storage drive **1014** represents a floppy disk drive, a magnetic tape drive, a compact disk drive, an optical storage device, tape backup, etc.

Removable storage drive **1014** interacts with a removable storage unit **1016**. Removable storage unit **1016** includes a computer useable or readable storage medium **1064**A having stored therein computer software **1068**B (control logic) and/or data. Removable storage unit **1016** represents a floppy disk, magnetic tape, compact disk, DVD, optical storage disk, or any other computer data storage device. Removable storage drive **1014** reads from and/or writes to removable storage unit **1016** in a well-known manner.

Computer **1002** also includes input/output/display devices **1066**, such as monitors, keyboards, pointing devices, Bluetooth devices, etc.

Computer **1002** farther includes a communication or network interface **1018**. Network interface **1018** enables computer **1002** to communicate with remote devices. For example, network interface **1018** allows computer **1002** to communicate over communication networks or mediums **1064**B (representing a form of a computer useable or readable medium), such as LANs, WANs, the Internet, etc. Network interface **1018** may interface with remote sites or networks via wired or wireless connections.

Control logic **1068**C may be transmitted to and from computer **1002** via communication medium **1064**B.

Any tangible apparatus or article of manufacture comprising a computer useable or readable medium having control logic (software) stored therein is referred to herein as a computer program product or program storage device. This includes, but is not limited to, computer **1002**, main memory **1008**, secondary storage devices **1010** and removable storage unit **1016**. Such computer program products, having control logic stored therein that, when executed by one or more data processing devices, cause such data processing devices to operate as described herein, represent the embodiments.

Embodiments can work with software, hardware, and/or operating system implementations other than those described herein. Any software, hardware, and operating system implementations suitable for performing the functions described herein can be used. Embodiments are applicable to both a client and to a server or a combination of both.

The Summary and Abstract sections may set forth one or more but not all embodiments as contemplated by the inventor(s), and thus, are not intended to limit the embodiments and the appended claims in any way.

The embodiments have been described above with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed.

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments that others can, by applying knowledge within the skill of the art, readily modify and/or adapt for various applications such specific embodiments, without undue experimentation, without departing from the general concept of the embodiments. Therefore, such adaptations and modifications are intended to be within the meaning and range of equivalents of the disclosed embodiments, based on the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and not of limitation, such that the terminology or phraseology of the present specification is to be interpreted by the skilled artisan in light of the teachings and guidance.

The breadth and scope of the embodiments should not be limited by any of the above-described embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

**1**. A computer-implemented method, comprising:

(A) sending a request from a source node to intermediate nodes directly connected to the source node based on the source node not having a direct route to a destination node in order to determine whether the intermediate nodes have a route to the destination node, wherein the source node has no prior knowledge of a route from the source node to the destination node;

(B) receiving one or more routing scores, at the source node from the intermediate nodes directly connected to the source node, indicating whether a direct route or indirect route to the destination node exists from each intermediate node, wherein a routing score for each intermediate node is based at least on hardware capabilities, available applications, and networking capabilities of each intermediate node;

(C) identifying a number of route paths from each intermediate node to the destination node based on the received one or more routing scores;

(D) selecting, by the source node, a particular intermediate node from the intermediate nodes based on the particular intermediate node's associated route path score, wherein the particular intermediate node's route path score is computed based on the particular intermediate node's routing score, one or more reported routing scores from other nodes associated with the particular intermediate node, and the number of identified route paths from the particular intermediate node to the destination node;

(E) sending, by the source node, data for the destination node to the selected intermediate node; and

(F) repeating steps (A) to (E) at the selected intermediate node until a route to the destination node is found and the data is transmitted to the destination node, wherein the selected intermediate node becomes a new source node.

**2**. The method of claim **1**, wherein the routing score is based on a magnitude of contiguous nodes and quality of transmission media.

**3**. The method of claim **1**, wherein communication between the source node and the intermediate nodes takes place over one or more types of networks available to the source node and the intermediate nodes.

**4**. The method of claim **1**, further comprising:

determining availability of one or more processing devices for use by the source node and an intermediate node that is directly connected to the source node;

determining network capabilities of the source node and the intermediate node; and

determining a number of other nodes directly connected to the source node and the intermediate node.

**5**. The method of claim **4**, further comprising:

determining reliability of a communication route from the source node to the other nodes and the particular intermediate node, the reliability based on quality of transmission media available to the source node, the other nodes and the particular intermediate node.

**6**. The method of claim **1**, further comprising:

instantiating a communication module on the source node, the communication module configured to perform the sending, receiving, identifying, selecting, sending and repeating, the communication module capable of communicating with other communication modules to establish an ad hoc independent network.

**7**. A computer-based system, comprising:

a memory; and

at least one processor coupled to the memory and configured to:

(A) send a request from a source node to intermediate nodes directly connected to the source node based on the source node not having a direct route to a destination node in order to determine whether the intermediate nodes have a route to the destination node, wherein the source node has no prior knowledge of a route from the source node to the destination node;

(B) receive one or more routing scores, at the source node from the intermediate nodes directly connected to the source node, indicating whether a direct route or indirect route to the destination node exists from each intermediate node, wherein a routing score for each intermediate node is based at least on hardware capabilities, available applications, and networking capabilities of each intermediate node;

(C) identify a number of route paths from each intermediate node to the destination node based on the received one or more routing scores;

(D) select, by the source node, a particular intermediate node from the intermediate nodes based on the particular intermediate node's associated route path score, wherein the particular intermediate node's route path score is computed based on the particular intermediate node's routing score, one or more reported routing scores from other nodes associated with the particular intermediate node, and the number of identified route paths from the particular intermediate node to the destination node;

(E) send, by the source node, data for the destination node to the selected intermediate node; and

(F) repeat steps (A) to (E) at the selected intermediate node until a route to the destination node is found and the data is transmitted to the destination node, wherein the selected intermediate node becomes a new source node.

**8**. The system of claim **7**, wherein the routing score is based on a magnitude of contiguous nodes and quality of transmission media.

**9**. The system of claim **7**, wherein communication between the source node and the intermediate nodes takes place over one or more types of networks available to the source node and the intermediate nodes.

**10**. A computer storage apparatus encoded with a computer program, the program comprising instructions that when executed by data processing apparatus cause the data processing apparatus to perform operations, comprising:

(A) sending a request from a source node to intermediate nodes directly connected to the source node based on the source node not having a direct route to a destination node in order to determine whether the intermediate nodes have one or more routes to the destination node, wherein the source node has no prior knowledge of a route from the source node to the destination node;

(B) receiving one more routing scores, at the source node from the intermediate nodes directly connected to the source node, indicating whether a direct route or indirect route to the destination node exits from each intermediate node, wherein a routing score for each intermediate node is based at least on hardware capabilities, available applications, and networking capabilities of each intermediate node;

(C) identifying a number of route paths from each intermediate node to the destination node based on the received one or more routing scores;

(D) selecting, by the source node, a particular intermediate node from the intermediate nodes based on the particular intermediate node's associated route path score, wherein the particular intermediate node's route path score is computed based on the particular intermediate node's routing score, one or more reported routing scores from other nodes associated with the particular intermediate node, and the number of identified route paths from the particular intermediate node to the destination node;

(E) sending, by the source node, data for the destination node to the selected intermediate node; and

(F) repeating steps (A) to (E) at the selected intermediate node until a route to the destination node is found and the data is transmitted to the destination node, wherein the selected intermediate node becomes a new source node.

**11**. The computer storage apparatus of claim **10**, wherein routing score is based on a magnitude of contiguous nodes and quality of transmission media.

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